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(54) **Locating positions on maps**

(57) In order to enable one's position to be easily found on a traditional map having its own co-ordinate system distinct from a wide-area co-ordinate system, data is associated with the map from which the relationship between the map co-ordinate system and the wide-area co-ordinate system can be determined and.an apparatus is provided which has a reader 18 for reading the data associated with the map. The apparatus also has a memory 34 for storing the read data, a GPS receiver 30 for receiving transmissions from GPS satellites and determining the position of the receiving means in terms of the wide-area co-ordinate system, a processor 28 for processing the determined wide-area co-ordinate position and the stored data to determine the position of the receiving means in terms of the map co-ordinate system, and a display 24 or the like for annunciating to a user the determined map co-ordinate position. The data associated with the map preferably also includes information on the area covered by the map. The map may be one of a series of maps or part of an atlas, the data relating to all of the maps in the series or atlas.

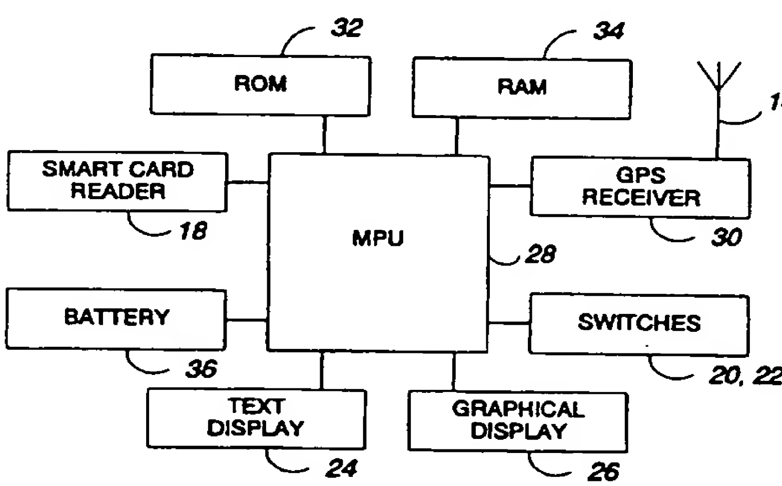


FIG. 4

GB 2 307 553 A

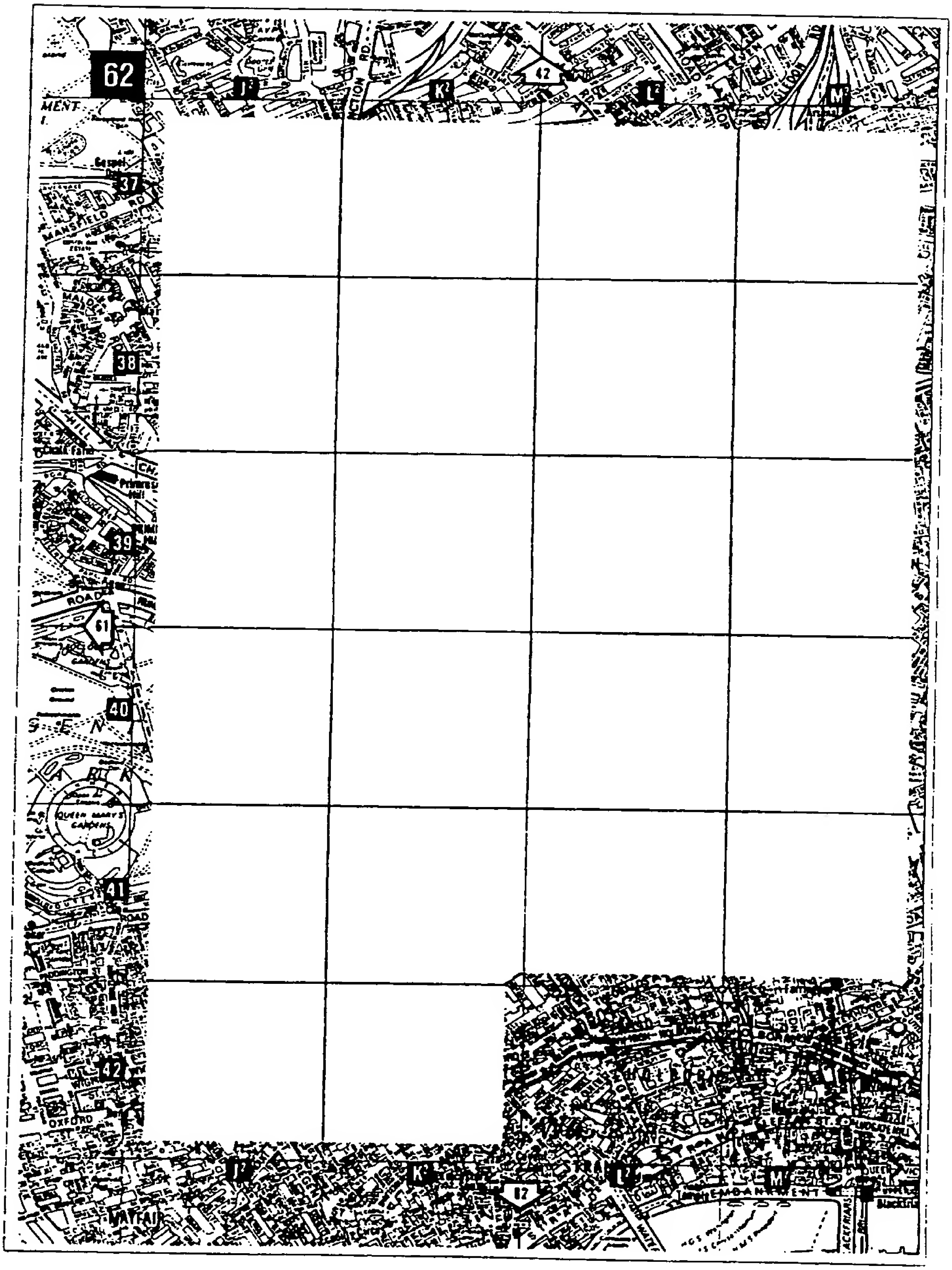

FIG. 1

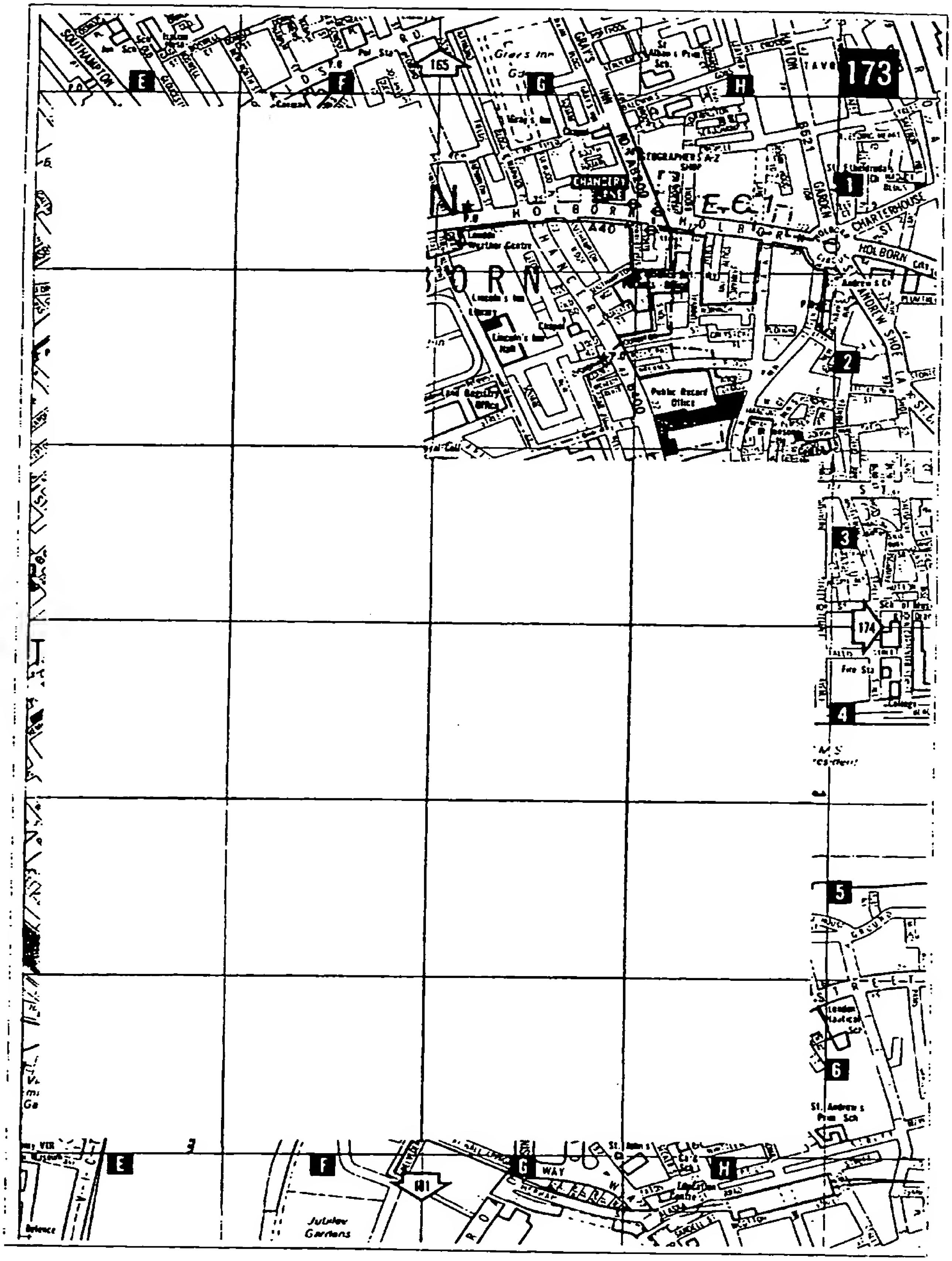
173
165
174
181
E
F
G
H
1
2
3
4
5
6
SOUTHAMPTON
Grays Inn
HOLBORN
CHANCERY
A40
CHARTERHOUSE
Public Record Office
Fire Sta
Jubilee Gardens
London Nautical Sch
St. Andrew's Prim Sch

FIG. 2

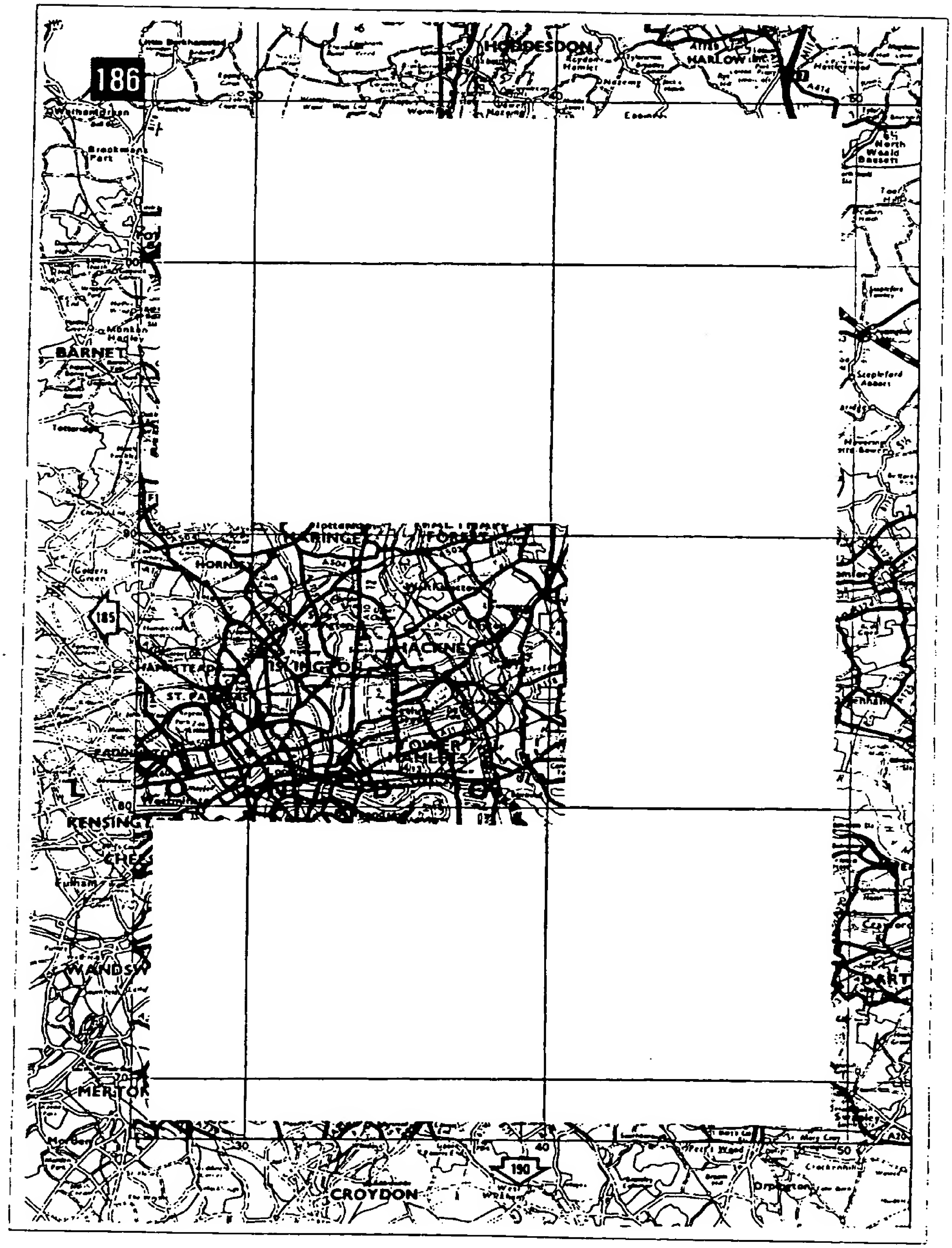
186
HODDESDON
HARLOW
BARNET
185
KENSING
WANDSW
MERTON
CROYDON
190
30
40
50

FIG. 3

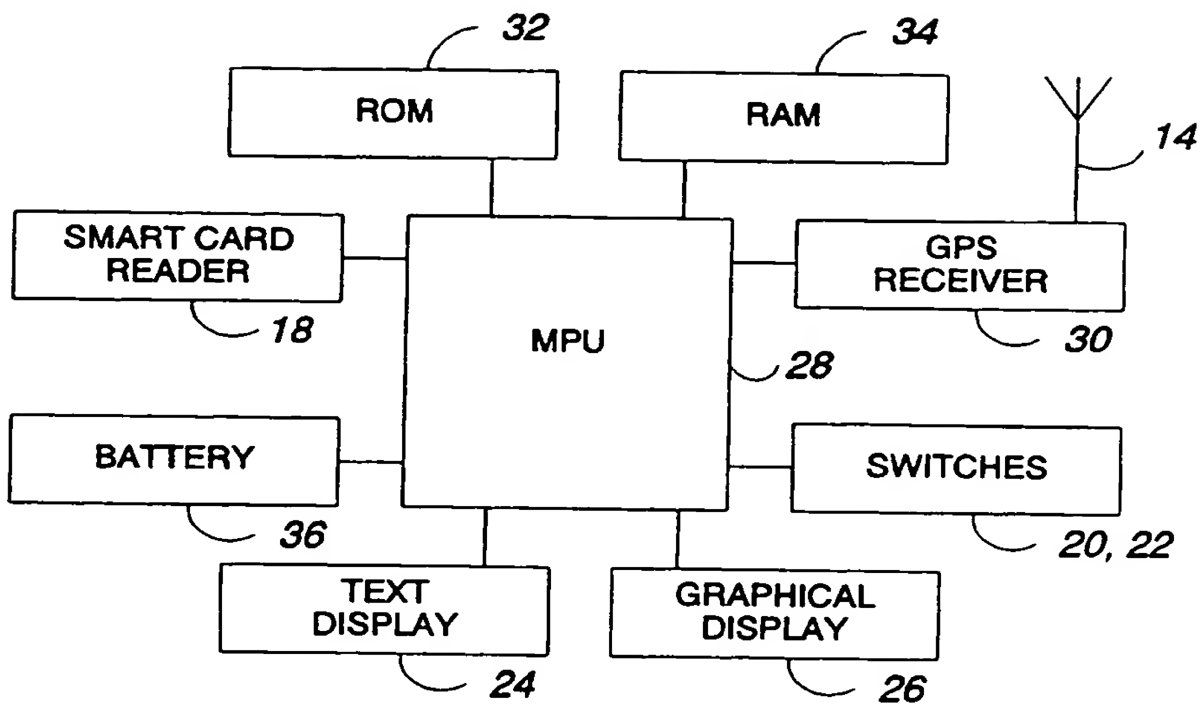
32
ROM
34
RAM
14
SMART CARD READER
18
MPU
28
GPS RECEIVER
30
BATTERY
36
SWITCHES
20, 22
TEXT DISPLAY
24
GRAPHICAL DISPLAY
26

FIG. 4

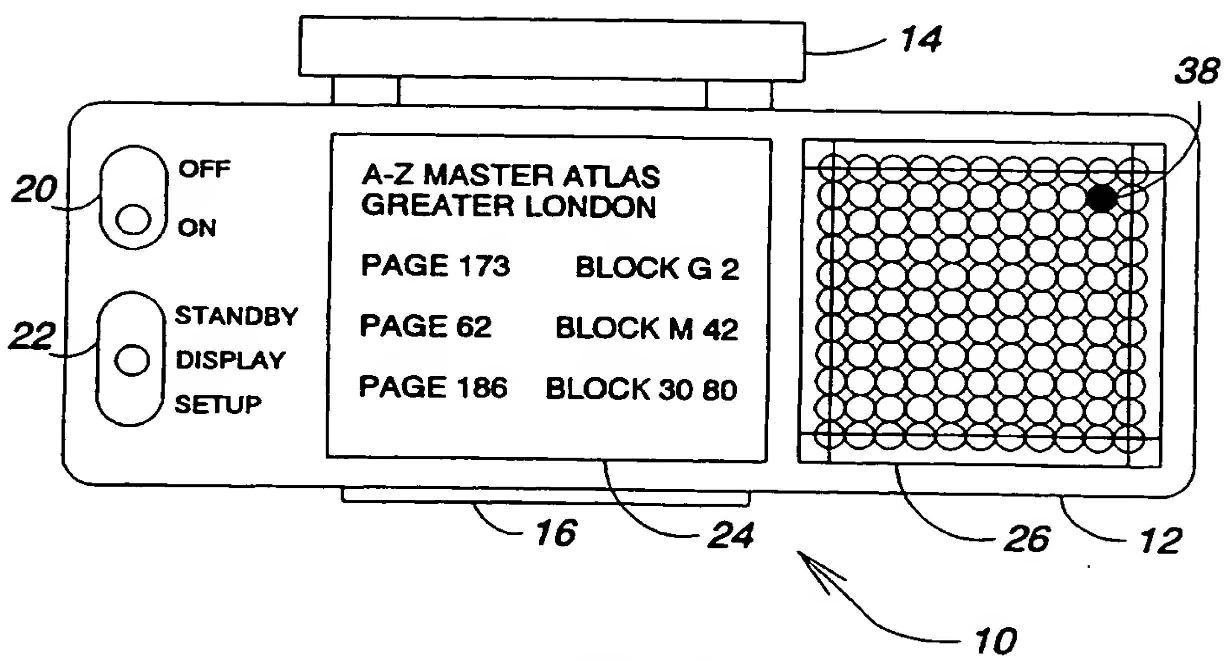
14
38
20
OFF
ON
22
STANDBY
DISPLAY
SETUP
A-Z MASTER ATLAS
GREATER LONDON
PAGE 173
BLOCK G 2
PAGE 62
BLOCK M 42
PAGE 186
BLOCK 30 80
16
24
26
12
10

FIG. 5

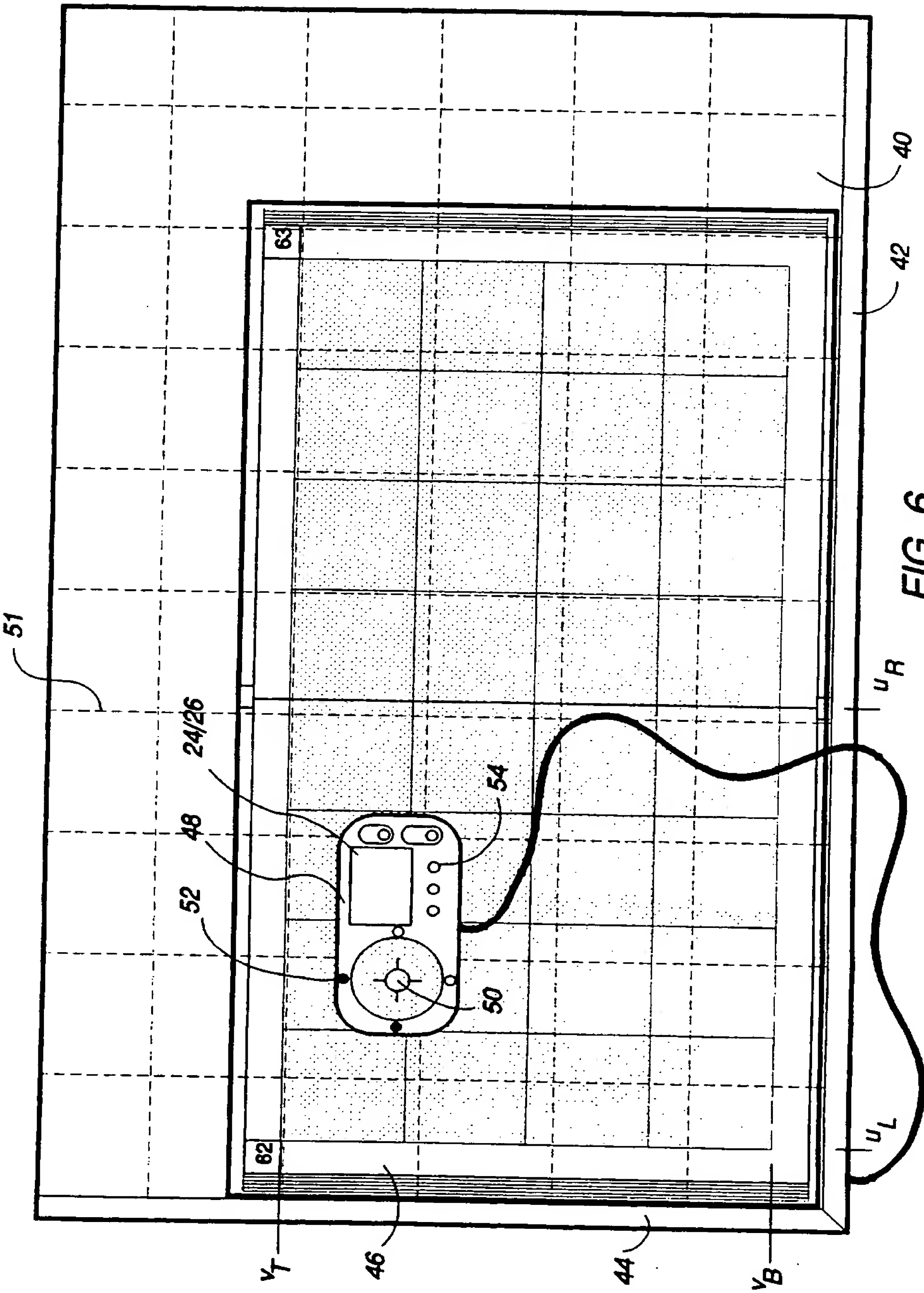


FIG. 6

2307553

## TITLE

Locating Positions on Maps

## DESCRIPTION

This invention relates to the location of positions on maps.

### Background to the Invention

Various systems are on the market for facilitating the location of one's position on a map. One example, called the Silva GPS Compass, marketed by Silva Sweden AB, of Sollentuna, Sweden, is a portable device which includes a global positioning system ("GPS") receiver and can display the current position of the receiver in terms of longitude and latitude with an accuracy of about 100m under the current level of "selective availability" applied by the US Department of Defense who operate GPS. When used with a map having longitude and latitude grid lines, one's position on the map can be located. However, there are two main disadvantages with this system. First, many maps (particularly road and street atlases and street plans) do not have any longitude and latitude markings whatsoever. Many other maps (for example Ordnance Survey ("OS") maps), although having longitude and latitude markings around their border and 5 minute graticule markings on the map, do not have any longitude and latitude grid lines drawn across the map. Thus it can be difficult to locate one's position on the map. Second, because longitude and latitude is a global co-ordinate system, much more information is provided by full longitude and latitude co-ordinates than is actually required to locate one's position on a map covering only a minuscule part of the surface area of the planet, and this can lead to confusion. For example, the old UK Patent Office building in Southampton Buildings, off Chancery Lane, London is situated at (51°30'59"N, -0°06'34"E), but it is difficult to locate that position on the relevant map in the OS 1:50,000 Landranger Second Series, Sheet 176, which covers latitudes 51°19'N to 51°41'N approximately and longitudes -0°03'E to -0°38'E approximately, but without any longitude and latitude grid lines.

A system which deals with this problem is marketed by Yeoman Marine Limited, of

Lymington, Hampshire, United Kingdom, under the name "Navigator's Yeoman". Also, an accessory is available for the Silva GPS compass, called the "Silva Yeoman Navimap", which has a similar effect. These systems use (a) a digitising table on which a traditional map can be placed, (b) a cursor which is movable across the map on the table and has indicators to indicate a required direction of movement, (c) a GPS receiver (or an input to receive a signal from a separate GPS receiver) from which one's current position can be determined, and (d) a processor which determines, from the cursor position on the digitising table and the current GPS position, which way the cursor should be moved so that it is over the current position and activates the indicator lights on the cursor accordingly. Whilst this system has the advantages that it can be used with any traditional map to any scale and of any part of the world, and one's current position can be located by following the indicators rather than thinking in terms of latitude and longitude, it does suffer from two disadvantages. First, before it can be used, the map must be manually referenced with respect to the digitising table so that the processor can translate between the latitude and longitude co-ordinates obtained from the GPS receiver and the co-ordinates of the digitiser table. Referencing can be performed by placing the cursor at two (and preferably three) positions on the chart, and at each position instructing the processor with the latitude and longitude co-ordinates of that position. Alternatively, when used for relative, rather than absolute, positioning when one's current position on the map is known, referencing can be carried out by registering the cursor on the current known position on map and then indicating to the apparatus the north direction of the map and its scale. Second, it requires the use of a digitising table which is as large as the map, or at least as large as a folded portion of the map which is to be viewed at one time without re-referencing.

One solution to these problems is to "computerise" the map. In the SkyMap system marketed by Skyforce Avionics Limited of Ramsgate, Kent, United Kingdom, which is primarily designed for aircraft navigation, a representation of the map is held in computer memory. The current position is determined using a GPS receiver, and a relevant part of the map, together with the current position, is displayed on a liquid crystal graphic display. The disadvantages of this sort of system are that (a) it would be extremely expensive if a large, high-resolution, map and colour display were to be used; and (b) many people prefer to use a traditional map. The SkyMap system also has the ability to

display the full OS grid co-ordinates of the current position so that the position can be located on an OS map. However, OS maps are not indexed according to the grid references covered, only according to sheet numbers, and the sheet numbers depend on the scale and series of the maps. Therefore it is not straightforward to select the appropriate map. Also, for a resolution of 100m, the full eight digit (or two letter and six digit) OS grid reference is not needed and not normally used when referring to a particular 1:50,000 sheet, and therefore providing all eight digits can lead to unnecessary confusion.

The present invention is concerned with dealing with the problems mentioned above of the known systems.

## Definitions of Terms used in this Specification

In this specification, the following terms are intended to have the following meanings:

"Traditional map" means a map which is printed on paper, linen, plastics sheet or the like.

"Map co-ordinate system" means a system of co-ordinates which are normally used to define a position on a particular map, and differs from a "Wide-area co-ordinate system" which includes the longitude and latitude system for defining positions on the earth's surface, but also includes other co-ordinate systems. For example, when considering a single map in the OS 1:50,000 series, for instance Sheet 176 mentioned above, the co-ordinates (312, 815) are co-ordinates according to the map co-ordinate system for that map, and differ not only from the co-ordinates (51.5164°N, -0.1095°E) according to the longitude and latitude co-ordinate system but also from the full OS co-ordinates (5312, 1815) or (TQ, 312, 815) according to the complete OS co-ordinate system.

"Wide-area position transmitting system" means a system which transmits signals which can be received over a large area and which can be processed so as to determine the receiver's position in terms of a wide-area co-ordinate system. An example of a wide-area position transmitting system is "GPS", which is operated by the US Department of Defense and comprises a couple of dozen or so transmitters which orbit the earth and transmit signals. When the signals from three or more transmitters are being received at a single site, they can be processed so as to determine the position of that site in terms of

longitude and latitude. However, the term "wide-area position transmitting system" is intended to include not only other satellite positioning systems, but also terrestrial positioning systems which rely on transmissions from land-based transmitters, and from which one's position in terms of a wide-area co-ordinate system can be determined.

## Summary of the Invention

In accordance with a first aspect of the present invention, there is provided a position locating system, comprising: a traditional map having its own co-ordinate system distinct from the wide-area co-ordinate system; data associated with the map (e.g. in the form of a bar code, magnetic stripe, smart card or encoded text) from which the relationship between the map co-ordinate system and wide-area co-ordinate system can be determined; and an apparatus comprising: means for receiving the data associated with the map; means for storing the received data; means for receiving transmissions from a wide-area position transmission system and determining therefrom the position of the receiving means in terms of the wide-area co-ordinate system; means for processing the determined wide-area co-ordinate position and the stored data to determine the position of the receiving means in terms of the map co-ordinate system; and means (e.g. a display or speech synthesiser) for annunciating to a user the determined map co-ordinate position.

The invention therefore provides the following advantages over the known systems described above:

1. There is no need for a digitising surface or the like, although in one version of the invention a digitising surface may be employed.

2. Traditional maps can be used, the only requirement being the additional data associated with the map, this being possible at low cost.

3. The user does not have any difficulty in selecting the appropriate map.

4. The user does not need to concern themself with latitude and longitude, but instead co-ordinate data is provided which is more relevant to the map being used. Using the example given above, instead of (or in addition to) being presented with the latitude and longitude co-ordinates (51°30'59"N, -0°06'34"E), the user might instead be presented with the abbreviated OS grid block for the position on Sheet

176, i.e. "(31, 81)" or with the abbreviated higher resolution grid reference "(312, 815)".

5. Referencing is carried out simply by entering the data associated with the map.

Preferably, the area covered by each map can be determined from the data associated with the map. The apparatus can then avoid attempting to determine the map co-ordinates of a position which is not covered by the map.

In one version of the invention, the map is one of a series of such maps; and the relationship between the co-ordinate system(s) of the maps and the wide-area co-ordinate system can be determined from the data associated with the maps. In this case also, the area covered by each map can preferably be determined from the data. The processing means is preferably operable to determine (a) the identity of that map, or at least one of those maps, which cover the position of the receiving means, and (b) the position of the receiving means on that map in terms of the co-ordinate system of that map; the annunciating means being operable to annunciate to the user (a) the identity of that map and (b) the determined position in terms of the co-ordinate system of that map. Thus, for example, in the case of the OS 1:50,000 Landranger Second Series, the data for all two hundred and four sheets in the series may be stored, and in the case of the position mentioned above, the annunciation may be in the form "Sheet 176, grid block (31, 81)."

In the case where some portions of the maps overlap, and in the case of a position falling on more than one of the maps: the processing means is preferably operable to determine (a) the identity of two or more of the maps which cover the position of the receiving means, and (b) the position(s) of the receiving means on those maps in terms of the co-ordinate system(s) of those maps; the annunciating means being operable to annunciate to the user (a) the identities of those maps and (b) each determined position in terms of the co-ordinate position of the respective map.

Not all of the maps in the series or atlas need be to the same scale, and in this case the data associated with the maps may take into account the different scales of the maps. For example, the Geographers' A-Z Master Atlas of Greater London, Edition 4(B), has a first set of maps on pages 2 to 160 covering Greater London to a scale of 3" to 1 mile (1:21,120), a second set of maps on pages 162 to 183 covering central London to a larger

scale of 9" to 1 mile (1:7,040) and a third set of maps covering London and its environs to a smaller scale of 2½ miles to 1" (1:158,400). The site of the old UK Patent Office building off Chancery Lane is covered by all three sets of maps, on pages 62, 173 and 186, as shown in Figures 1, 2 and 3, respectively, of the accompanying drawings. In accordance with this feature of the invention, the position of that building could be annunciated as "Page 62, Block M 42", "Page 173, Block G 2" and "Page 186, Block (30, 80)", simultaneously, or one after another.

The invention is particularly advantageous in the case where the series of maps are bound together in the form of an atlas. The apparatus can then tell the user to which page of the atlas to turn, and where on that page to look.

In the case where the or each map is divided up into an array of blocks, the annunciating means is preferably operable to annunciate an identity of that one of the blocks containing the map position of the receiving means, as in the above example "Block M 42".

The annunciating means advantageously also includes means to annunciate the map position of the receiving means relative to the identified block. For example, the block could be notionally divided in ten in each of the x and y directions, and the location of the old Patent Office building could be annunciated as "Page 62, Block M 42, Position (1, 7)". However, this may cause confusion, for example as to whether it means 1/10 along and 7/10 up, or 1/10 up and 7/10 along. To deal with this, the relative position annunciating means may comprise a graphical display which can be activated to display the relative position in the block, or a see-through display which can be registered over the identified block on the map and which is operated to indicate the map position of the receiving means within that block.

The data associated with the map(s) is preferably provided on or in the map or atlas, for example in the form of a bar code or magnetic stripe printed on the map or inside cover of the atlas, or a smart card forming an additional page to the atlas, or which is removably inserted in a pocket or the like on the map or in the atlas.

The data associated with the map(s) may include at least one parameter related to the cartographic projection of the or each map, so that the system can accurately locate positions on maps employing different cartographic projections.

The data associated with the map(s) may be machine-readable, with the data receiving means of the apparatus comprising means for reading the machine-readable data. Alternatively, the data may be provided as user-readable encoded text, with the data receiving means of the apparatus comprising means (such as a keypad) to enable a user to enter the encoded text and means for decoding the entered text.

The system may further comprise: a digitising surface having its own co-ordinate system; means for registering the map, or one of the maps, or the atlas with respect to the digitising surface; a cursor which is movable with respect to the registered map or atlas; and means for determining the position of the cursor with respect to the digitising surface in terms of the digitising surface's co-ordinate system; the relationship between the digitising surface's co-ordinate system and the co-ordinate system of the map, or the map of the atlas, registered with respect to the digitising surface being determinable from the data associated with the map. In this case, the annunciating means may be operable to indicate a required direction of movement of the cursor towards the current position on the map.

Preferably, the storing means is also operable to store a target position; the processing means is also operable to calculate the distance between the stored position and the current position and/or the bearing of the stored and current positions relative to each other; and the annunciating means is also operable to annunciate the calculated distance and/or bearing.

In accordance with a second aspect of the present invention, there is provided a map *per se* having: its own co-ordinate system distinct from the wide-area co-ordinate system; and data associated with the map from which the relationship between the map and wide-area co-ordinate systems can be determined.

In accordance with a third aspect of the present invention, there is provided a series of maps *per se* having their own co-ordinate system(s) distinct from the wide-area co-ordinate system and data associated with the maps from which the relationship between the co-ordinate system(s) of the maps and the wide-area co-ordinate system can be determined.

In accordance with a fourth aspect of the present invention, there is provided a position

locating apparatus *per se*, comprising: means for receiving data associated with a traditional map having its own co-ordinate system distinct from the wide-area co-ordinate system from which data the relationship between the map and wide-area co-ordinate systems can be determined; means for storing the received data; means for receiving data representing a position in terms of the wide-area co-ordinate system; means for processing the received wide-area co-ordinate position and the stored data to determine the position in terms of the map co-ordinate system; and means for annunciating to a user the determined map co-ordinate position.

The apparatus may further comprise means for receiving transmissions from a wide-area position transmitting system, for determining therefrom the position of the receiving means in terms of the wide-area co-ordinate system, and supplying the determined position to the position data receiving means.

In accordance with a fifth aspect of the present invention, there is provided a data carrier *per se* associated with at least one map and containing data from which the relationship between (a) co-ordinate system(s) of the map(s) and the wide-area co-ordinate system can be determined, the data being machine-readable or being encoded user-readable text.

## Specific Description

A specific embodiment of the invention and some modifications and developments thereto will now be described by way of example with reference to the accompanying drawings, in which:

Figures 1-3 show portions of pages 62, 173 and 186, respectively, of the Master Atlas of Greater London, Edition 4(B), published by Geographers' A-Z Map Company Limited, Sevenoaks, Kent;

Figure 4 is a block diagram showing functional elements of one embodiment of apparatus for use in performing the invention;

Figure 5 is top view of the apparatus of Figure 4; and

Figure 6 is a top view of another embodiment of the apparatus.

Conversion of Wide-area Co-ordinates to Map Co-ordinates

In the remainder of this description:

$\theta$ and $\phi$ denote the wide area co-ordinates of a position on the surface of the earth in terms of longitude ($\theta$) and latitude ($\phi$) with the sign convention that east of the Greenwich meridian is positive and north of the equator is positive;

$\psi$ denotes the product of the longitude and the cosine of the latitude of a position on the surface of the earth, i.e.:

$$\psi = \theta.\cos\phi \qquad (1)$$

x and y denote coordinates (in the usual directions) of a position on a map in terms of the map's own co-ordinate system.

In the apparatus of the embodiments, is necessary to convert from ($\theta$, $\phi$) to (x, y). In a simplistic "flat-earth" model for maps covering a small part of the earth's surface, it can be assumed that, for a particular map, x and y are each linear functions of $\psi$ (= $\theta.\cos\phi$) and $\phi$, i.e.:

$$(x \quad y) = (\psi \quad \phi \quad 1).\begin{pmatrix} a & b \\ c & d \\ e & f \end{pmatrix} \qquad .....(2)$$

Assuming that the x direction of the map is approximately parallel to the lines of latitude, then in the conversion matrix above, the elements a and d relate predominantly to the scale of the map in the x and y directions, the elements e and f relate predominantly to the position of the map, and the elements b and c account for any skew between the x direction of the map and the lines of latitude. By taking the wide-area co-ordinates ($\theta_1$, $\phi_1$), ($\theta_2$, $\phi_2$), ($\theta_3$, $\phi_3$) of three positions on the surface of the earth and by taking the map co-ordinates ($x_1$, $y_1$), ($x_2$, $y_2$), ($x_3$, $y_3$) of the corresponding three positions on a particular map, it is possible to formulate six simultaneous equations derived from Formula 2 which can be represented by:

$$\begin{pmatrix} x_1 & y_1 \\ x_2 & y_2 \\ x_3 & y_3 \end{pmatrix} = \begin{pmatrix} \psi_1 & \phi_1 & 1 \\ \psi_2 & \phi_2 & 1 \\ \psi_3 & \phi_3 & 1 \end{pmatrix} . \begin{pmatrix} a & b \\ c & d \\ e & f \end{pmatrix} \qquad \text{.....(3)}$$

These simultaneous equations can then be solved to obtain the unknown values a to f of the conversion matrix by multiplying both sides by the inverse of the matrix containing the wide-area co-ordinates:

$$\begin{pmatrix} a & b \\ c & d \\ e & f \end{pmatrix} = \begin{pmatrix} \psi_1 & \phi_1 & 1 \\ \psi_2 & \phi_2 & 1 \\ \psi_3 & \phi_3 & 1 \end{pmatrix}^{-1} . \begin{pmatrix} x_1 & y_1 \\ x_2 & y_2 \\ x_3 & y_3 \end{pmatrix} \qquad \text{.....(4)}$$

$$\therefore \begin{pmatrix} a & b \\ c & d \\ e & f \end{pmatrix} = \frac{\begin{pmatrix} \phi_2-\phi_3 & \phi_3-\phi_1 & \phi_1-\phi_2 \\ \psi_3-\psi_2 & \psi_1-\psi_3 & \psi_2-\psi_1 \\ \psi_2\phi_3-\psi_3\phi_2 & \psi_3\phi_1-\psi_1\phi_3 & \psi_1\phi_2-\psi_2\phi_1 \end{pmatrix} . \begin{pmatrix} x_1 & y_1 \\ x_2 & y_2 \\ x_3 & y_3 \end{pmatrix}}{\begin{pmatrix} \psi_1 & \psi_2 & \psi_3 \end{pmatrix} . \begin{pmatrix} \phi_2-\phi_3 \\ \phi_3-\phi_1 \\ \phi_1-\phi_2 \end{pmatrix}} \qquad (5)$$

As an example, considering the above-mentioned OS map sheet 176, and taking the three positions as the bottom-left corner, bottom-right corner and the midpoint along the top edge of the map, this gives:

$(x_1, y_1) = (495\text{km}, 160\text{km})$ $\quad(\theta_1, \phi_1) = (-0.6367°, 51.3308°)$ $\quad\therefore \psi_1 = -0.39782°$

$(x_2, y_2) = (535\text{km}, 160\text{km})$ $\quad(\theta_2, \phi_2) = (-0.0628°, 51.3225°)$ $\quad\therefore \psi_2 = -0.03925°$

$(x_3, y_3) = (515\text{km}, 200\text{km})$ $\quad(\theta_3, \phi_3) = (-0.3358°, 51.6860°)$ $\quad\therefore \psi_3 = -0.20819°$

Using formula 5, the conversion matrix for sheet 176 is therefore:

$$\begin{pmatrix} a & b \\ c & d \\ e & f \end{pmatrix} = \begin{pmatrix} 111.47994\,km/° & 2.574881\,km/° \\ -3.2092944\,km/° & 111.23796\,km/° \\ 704.10065\,km & -5548.9032\,km \end{pmatrix} \qquad (6)$$

To evaluate the accuracy of conversion, the wide-area co-ordinates for the other two corners of sheet 176 are $(\theta_4, \phi_4) = (-0.6250°, 51.6903°)$ and therefore $\psi_4 = -0.38744°$ at the top-left corner and $(\theta_5, \phi_5) = (-0.0464°, 51.6817°)$ and therefore $\psi_5 = -0.02877°$ at the top-right corner. Applying the conversion formula 2 using the conversion matrix of formula 6 for sheet 176 gives map co-ordinates $(x_4, y_4) = (495.019\text{km}, 200.023\text{km})$ and $(x_5, y_5) = (535.032\text{km}, 199.990\text{km})$. On the map, the co-ordinates of these two corners are, in fact, (495km, 200km) and (535km, 200km), and thus there are discrepancies of:

$$\sqrt{((495.019 - 495)^2 + (200.023 - 200)^2)}\ \text{km} = 30\text{m; and}$$

$$\sqrt{((535.032 - 535)^2 + (199.990 - 200)^2)}\ \text{km} = 34\text{m}$$

which are less than the inaccuracy provided by GPS and therefore not a limiting factor. On the paper of the map, the discrepancies are 1/50,000 of these amounts, that is 0.60mm and 0.68mm, respectively.

Testing whether a Position is within the Boundary of a Map

When the invention is applied to a single map, it is preferable that a determination is made as to whether the current position is within the boundary of the map, so as to avoid attempting to calculate and annunciate map co-ordinates which are not covered by the map. Also, when the invention is applied to a series of maps, it is preferable that a determination is made as to whether the current position is within the boundary of any of the maps, and if so which one(s). Due to the nature of the longitude and latitude wide-area co-ordinate system, relatively few maps have boundaries which extend along lines of constant longitude or constant latitude. It would be possible to develop a formula defining each boundary line in terms of both longitude and latitude. However, the invention preferably takes advantage of the fact that the majority of maps are square or rectangular and their boundaries run parallel and at right angles to the map's co-ordinate system. Accordingly, it will be appreciated, from formula 2, that if the co-ordinates of the bottom-left and top-right corners of a map are $(x_L, y_B)$ and $(x_R, y_T)$, respectively, then a position having wide-area co-ordinates $(\theta, \phi)$ and accordingly a value $\psi = \theta.\cos\phi$ will fall on the map if it satisfies both of the relationships:

$$x_L \le a\psi + c\phi + e \le x_R \tag{7}$$

$$y_B \le b\psi + d\phi + f \le y_T \tag{8}$$

Thus, given the wide-area co-ordinates ($\theta$, $\phi$) of a position, the values a to f of the conversion matrix for a particular map, and the co-ordinates ($x_L$, $y_B$) and ($x_R$, $y_T$) in terms of the map's co-ordinate system of two, diagonally-opposite corners of the map, it is simple to test whether that position falls on that map.

The mapped region of some maps is not a simple rectangle or square. For example, maps often have a small legend rectangle at one corner. In this case, the mapped area can be divided up into, say, two rectangular sub-maps, each having the same conversion matrix, but with different values of $x_L$, $x_R$, $y_T$ and $y_B$.

Different Co-ordinate Styles

It will be appreciated that different maps have different styles for representing their co-ordinates. For example, the co-ordinates of the grid lines on most OS sheets, in each of the x and y directions, consist in full of a three digit number, e.g. the old Patent Office site mentioned above is in OS grid block (531, 181), but the most significant digits are not normally used and are usually marked only at the corners of the map. In the first set of maps in the A-Z Master Atlas of Greater London mentioned above, the y co-ordinates of the map blocks are numerical but increasing in the downwards direction, as seen in Figure 1, and the x co-ordinates are alphabetical with repeats, but the same letter is never repeated on two adjacent pages of the atlas. As shown in Figure 2, in the second set of maps of that atlas, the x co-ordinates of the map blocks are alphabetical, but re-starting at "A" on each double page. As shown in Figure 3, the third set of maps are marked with OS grid lines at 10 km intervals. In the embodiment of the invention, all map co-ordinates (x, y) are stored and processed numerically until they are displayed, when they are converted into their proper form (X, Y) in dependence upon co-ordinate style codes $S_x$ and $S_y$ for the map or set of maps in question.

The Data Associated with a Map or Maps

In the case of a single map, the data which is provided may comprise:

a "single map" flag set at 1 indicating that the data relates to a single map;

the six values a to f of the conversion matrix;

the four values $x_L$, $x_R$, $y_T$ and $y_B$ defining the map's boundaries;

two codes $S_x$, $S_y$ representing the x and y co-ordinate styles of the map; and

the name of the map.

In the example given above, the data might consist of:

111.47994; 2.574881; -3.2092944; 111.23796; 704.10065; -5548.9032; 495; 535; 160; 200; $S_x$; $S_y$; "OS Landranger Series 2 Sheet 176"

The eleven data items may be printed in the form of a bar code or magnetic stripe on the map.

In the case of a series of maps, the data which is provided may comprise:-

the single map flag, but set to 0 indicating that the data relates to more than one map;

the name of the series of maps or the atlas (e.g. "A-Z Master Atlas Greater London");

the number S of sets of maps in the series or atlas (e.g. "3");

{for each set of the S sets:-}

two codes representing the x and y co-ordinate styles of the maps in that set;

the number M of maps in that set;

{for each map in that set:-}

the name of that map (e.g. "Page 62");

the six values a to f of the conversion matrix for that map; and

the four values $x_L$, $x_R$, $y_T$ and $y_B$ defining that map's boundaries.

{next map}

{next set}

Construction of the Apparatus

Referring to Figures 4 and 5, the apparatus 10 is portable, of so-called "palm-top" size, and comprises a casing 12 having a GPS antenna 14 mounted on its top edge and a slot 16 providing access to a smart card reader 18 in its bottom edge. The smart card may form part of a special page of an atlas, or may be removably inserted in a pocket inside the cover of the atlas. Alternatively, the smart card which is insertable into the slot 16 may be a completely separate article, for example containing the data of all 204 sheets in the OS Landranger Second Series. The top face of the casing 12 has: an on/off switch 20; a mode switch 22 having standby, display and setup positions; a liquid crystal text display 24; and a liquid crystal graphical display 26. Alternatively, these two displays could be combined into one. The graphical display 24 comprises an 11 x 11 array of pixels, any one 38 of which can be activated to display a position within a grid block.

Referring in particular to Figure 4, the casing also contains: a microprocessor unit 28; a GPS receiver 30; ROM 32; RAM 34; and a battery 36. An external power socket may also be provided to receive power from a mains adaptor to charge the battery or from a vehicle's cigar lighter socket.

Operation of the Apparatus

When the on/off switch 20 is "on", the MPU 28 operates in accordance with a program stored in the ROM 32. When the mode switch 22 is at "setup", the smart card reader 18 is activated, and it can read the data mentioned above associated with the map, series of maps or atlas, and supply it to the MPU 28 for processing and storage in the RAM 34. The GPS receiver 30 is connected to the GPS antenna 14, and when the mode switch 22 is at "display", the GPS receiver 30 is activated, and when it receives signals from three or more GPS satellites it supplies the current wide-area co-ordinates ($\theta$, $\phi$) to the MPU. When the mode switch 22 is at "display" or "setup", the LCDs 24, 26 are activated. When the mode switch 22 is at "standby", the smart-card reader 18, GPS receiver 30 and LCDs 24, 26 are inactive, but the data which has been read continues to be stored in the RAM 34.

The program stored in the ROM 32 causes the apparatus to operate according to the

following routines of steps while the on/off switch is "on":-

Main Routine

R1 Set to 0 a "data present" flag F indicating whether data associated with a map has been read.

R2 If the mode switch 22 is at "display" jump to step R5, or if at "setup" call the Setup subroutine, otherwise if the mode switch 22 is at "standby" continue.

R3 If the displays 24, 26 are on, or the GPS receiver 30 is on, switch them off.

R4 Loop back to step R2.

R5 If the data present flag F is 0, activate the text display 24 to invite the user to switch to "setup" and loop back to step R2, otherwise continue.

R6 If the GPS receiver 30 is off, switch it on.

R7 If the GPS receiver 30 is not producing wide-area co-ordinate signals, activate the text display 24 to inform the user that the GPS position is awaited and loop back to step R2, otherwise continue.

R8 Store the wide-area co-ordinates ($\theta$, $\phi$) from the GPS receiver 30 in the RAM 34.

R9 From the stored wide-area co-ordinates ($\theta$, $\phi$) and Formula 1, calculate the value of $\psi$ and store it in the RAM 34.

R10 If the single map flag in the read data is 1, call the Single Calculation subroutine, otherwise call the Multi Calculation subroutine.

R11 Loop back to step R2.

Setup Subroutine

S1 Switch on the smart card reader.

S2 Activate the text display 24 to invite the user to insert the smart card associated with the map, series of maps, or atlas to be used.

S3 Loop on this step until data has successfully been read, and then continue.

S4 Store the read data in the RAM 34.

S5 Switch off the smart card reader.

S6 Set the data present flag to 1.

S7 Activate the text display 24 to inform the user of the name of the map, series of maps or atlas, and that the data has been successfully read.

S8 If the mode switch is at "setup", loop on this step, otherwise continue.

S9 Return to the main routine.

Single Calculation Subroutine

C1 If, from Formulae 7 and 8 and the stored data, it is determined that the current position is not covered by the map, activate the text display 24 to inform the user that the current position is off the map and return to the main routine, otherwise continue.

C2 From Formula 2 and the stored data, calculate the map position (x, y) and store it in the RAM 34.

C3 From the stored data, convert the style of the map position to (X, Y) and store it in the RAM 34.

C4 Calculate a fractional part ($f_x$, $f_y$) of the map position within the grid block (X, Y) and store it in the RAM 34.

C5 Activate the text display 24 to inform the user of the name of the map and the stored map position (X, Y).

C6 Activate that pixel 38 of the graphical display 26 corresponding to the stored fractional part ($f_x$, $f_y$) of the map position.

C7 Return to the main routine.

Multi Calculation Subroutine

M1 Set a counter C to 0.

M2 For each set s of the S sets of maps:-

M3 For each map m in the M maps of set s:-

M4 If, from Formulae 7 and 8 and the stored data, it is determined that the current position is not covered by that map m in that set s, jump to step M10.

M5 Increment the counter C.

M6 Store the name of map m in set s as $N_C$.

M7 From Formula 2 and the stored data, calculate the position $(x_C, y_C)$ and store it in the RAM 34.

M8 From the stored data, convert the style of the map position to $(X_C, Y_C)$ and store it in the RAM 34.

M9 If C=1, calculate the fractional part $(f_x, f_y)$ of the map position within the grid block $(X_1, Y_1)$ and store it in the RAM 34.

M10 Next m

M11 Next s

M12 Activate the text display 24 to inform the user of the name of the series of maps or atlas.

M13 For each map I from 1 to C:-

M14 Activate the text display 24 to inform the user of the name $N_i$ of the map.

M15 Activate the text display 24 to inform the user of the stored map position $(X_i, Y_i)$.

M16 Next I.

M17 Activate that pixel 38 of the graphical display 26 corresponding to the stored fractional part ($f_x$, $f_y$) of the map position on map $N_1$.

M18 Return to the main routine.

## Example Display

In the case of the position of the old UK Patent Office Building on the A-Z Master Atlas of Greater London, as mentioned above, an example of the display which might be produced is shown in Figure 5. The top part of the text display 24 shows the name of the atlas. This is followed by the names of those maps (page numbers) which show that position and, for each page number, the grid block which contains that position. The example display assumes that the data which is read from the atlas contains the data for the large scale set of maps, then for the medium scale set of maps, and then for the small scale set of maps. The graphical display 26 shows the relative position within the grid block of the first map which is listed, i.e. within Block G 2 on Page 173.

## Second Embodiment

Figure 6 shows a second embodiment of the invention. A digitising tablet 40 has ledges 42, 44 along its bottom and left edges against which the bottom and left edges of a map or atlas 46 can be registered. A cursor 48 is movable over the atlas and incorporates many or all of the features of the apparatus 10 of Figure 5. The cursor 48 and digitising tablet 40 co-operate in a known way so that the MPU 28 can determine the position of a reference point 50 of the cursor 48 with respect to the co-ordinate system of the digitising tablet 40, as denoted by dashed lines 51 in the drawing. In this embodiment, the data which is associated with the atlas also includes, for each map, information relating the co-ordinate system of that map with the co-ordinate system of the digitising tablet 40 when the atlas is registered with the ledges 42, 44 and the atlas is open at the map in question. For example, in addition to giving the co-ordinates ($x_L$, $y_B$) and ($x_R$, $y_T$) of two diagonally opposite corners of the map in terms of the map's co-ordinate system for boundary testing purposes, as described above, the data may also include the co-ordinates ($u_L$, $v_B$) and ($u_R$, $v_T$), as shown in Figure 6, of those two corners in terms of the digitising tablet's co-ordinate system. Once the relationships between the three

co-ordinate systems have been established, the MPU 28 can, for example, determine the direction in which the cursor should be moved so as to lie over a particular point, and indicate that direction by illuminating one or two of four lights 52 on the cursor. (For further information about this technique and modifications thereto, reference is directed to patent application EP-A-0,268,628.) The particular point may be the current position, or it may be a target position which has been entered and stored in the RAM 34 by placing the cursor over that position on the map and pressing a push-button 54. Also, the MPU 28 can calculate the distance between the current position and the stored position, and the bearing of one with respect to the other, and display this information on the display 24.

## Modifications and Developments

It will be appreciated that many modifications and developments may be made to the embodiments described above. For example, the apparatus may be simplified so that it deals with only one map, or only one page of an atlas, at a time, the data for that map or page being read from, for example, a bar code or magnetic stripe printed on the map or page.

In the arrangements described above, the data associated with the map(s) is machine-readable. Alternatively, the data may be provided as user-readable encoded text, and the apparatus may have a key pad or the like to enable a user to enter the encoded text, the text then being decoded by the MPU 28.

In the case where more than one map or atlas page covers a particular position, the apparatus may be arranged to display the details (including the position in the grid block on the graphical display 26) of only a selected one of the maps or pages, but with an indication that others are available. A push button may then be provided so that the user can cycle through the available details. Also, in the case where the map positions relate to different sets of the maps, and the selected map ceases to cover the current position, the MPU 28 may be programmed initially to select for display another map from the same series.

As described above, the graphical display 26 shows only the current relative position in the grid block. Alternatively, it may be arranged also to show previous positions so that a

trail is built up as the user moves their position, with the current position displayed differently to the previous positions, for example blinking. In this case, a push button may be provided whose operation causes the previous positions to be cleared if the display becomes too cluttered.

The graphical display may be modified so that it is transparent and can be registered with the appropriate grid block of the map so as to show the current position in that grid block. In this case, the data which is associated with the map would include data from which the actual size of the grid blocks on the paper of the map can be determined.

In a simpler form of the apparatus, the graphical display may be omitted.

The apparatus may be modified so as to display the current position also in terms of latitude and longitude.

The data which is associated with each map may be encrypted, and the MPU 28 may be programmed to perform a suitable decryption algorithm so as to hinder the use of unauthorised data.

In the embodiment described above, the MPU 28 tests each of the maps in a predetermined order to determine which of the maps covers the current position. Once a map has been found which covers the current position, if that map then ceases to cover it, the current position should then be covered by a map covering an adjacent part of the earth's surface. Accordingly, the data provided for each map may also include information on the maps covering adjacent areas, and the MPU 28 may be programmed to use that information in order to increase the speed with which the next map may be found.

For maps drawn according to some cartographic projections, Formula 2 above based on a flat-earth model may not be appropriate. In order to deal with this, the MPU 28 may be programmed to be able to perform different transformation functions, for example for flat-earth, Mercator and transverse Mercator, and the data associated with each map or series of maps or atlas may include parameters defining the transformation function to be used for that map, or that series of maps or atlas, or for particular sets of maps in the series or atlas. Alternatively, the data may include the transformation function(s) itself, which is then loaded into the apparatus when the data is read.

The information which is provided so that the relationship between the wide-area co-ordinate system and the map's co-ordinate system need not be of the form described with reference to Formula 2 above. Instead, it may consist of the wide-area co-ordinates of a predetermined position on the map, the north direction on the map, and the scale of the map.

The apparatus need not include a GPS receiver, but instead may have an input to receive an output from a separate GPS receiver. Also, the apparatus may be built in to some other apparatus having other functions. Furthermore, the display may be separately housed, for example on the dashboard of a vehicle, whilst other parts of the apparatus are mounted elsewhere.

It will be appreciated that many other modifications and developments may also be made and that the description above is not to be taken as limiting the scope of the invention.

## CLAIMS

1. A position locating system, comprising:

a traditional map having its own co-ordinate system distinct from a wide-area co-ordinate system;

data associated with the map from which the relationship between the map co-ordinate system and the wide-area co-ordinate system can be determined; and

an apparatus comprising:

means for receiving the data associated with the map;

means for storing the received data;

means for receiving transmissions from a wide-area position transmitting system and determining therefrom the position of the receiving means in terms of the wide-area co-ordinate system;

means for processing the determined wide-area co-ordinate position and the stored data to determine the position of the receiving means in terms of the map co-ordinate system; and

means for annunciating to a user the determined map co-ordinate position.

2. A system as claimed in claim 1, wherein the area covered by the map can be determined from the data associated with the map.

3. A system as claimed in claim 1, wherein:

the map is one of a series of such maps; and

the relationship between the co-ordinate system(s) of the maps and the wide-area co-ordinate system can be determined from the data associated with the maps.

4. A system as claimed in claim 3, wherein the area covered by each map can be determined from the data associated with the maps.

5. A system as claimed in claim 3 or 4, wherein:

the processing means is operable to determine (a) the identity of that map, or at least one of those maps, which cover the position of the receiving means, and (b) the position of the receiving means on that map in terms of the co-ordinate system of that map; and

the annunciating means is operable to annunciate to the user (a) the identity of that map and (b) the determined position in terms of the co-ordinate position of that map.

6. A system as claimed in any of claims 3 to 5, wherein some portions of the maps overlap, and in the case of a position falling on more than one of the maps:

the processing means is operable to determine (a) the identity of two or more of the maps which cover the position of the receiving means, and (b) the position(s) of the receiving means on those maps in terms of the co-ordinate system(s) of those maps; and

the annunciating means is operable to annunciate to the user (a) the identities of those maps and (b) each determined position in terms of the co-ordinate system of the respective map.

7. A system as claimed in any of claims 3 to 6, wherein:

not all of the maps are to the same scale; and

the data associated with the maps takes into account the different scales of the maps.

8. A system as claimed in any of claims 3 to 7, wherein the maps in the series are bound together in the form of an atlas.

9. A system as claimed in any preceding claim, wherein:

the or each map is divided up into an array of blocks; and

the annunciating means is operable to annunciate an identity of that one of the blocks containing the map position of the receiving means.

10. A system as claimed in claim 9, wherein the annunciating means includes means to annunciate the map position of the receiving means relative to the identified block.

11. A system as claimed in claim 10, wherein the relative position annunciating means comprises a graphical display which can be activated to display the relative position in the block.

12. A system as claimed in claim 10, wherein the relative position annunciating means comprises a see-through display which can be registered over the identified block on the map and which is operated to indicate the map position of the receiving means within that block.

13. A system as claimed in any preceding claim, wherein the data associated with the map(s) is provided on or in the map or atlas.

14. A system as claimed in any preceding claim, wherein the data associated with the map(s) includes at least one parameter related to the cartographic projection of the or each map.

15. A system as claimed in any preceding claim, wherein the data associated with the map(s) is machine-readable, and the data receiving means of the apparatus comprises means for reading the machine-readable data.

16. A system as claimed in any of Claims 1 to 14, wherein the data associated with the map(s) is provided as user-readable encoded text, and the data receiving means of the apparatus comprises means to enable a user to enter the encoded text and means for decoding the entered text.

17. A system as claimed in any preceding claim, further comprising:

a digitising surface having its own co-ordinate system;

means for registering the map, or one of the maps, or the atlas with respect to the digitising surface;

a cursor which is movable with respect to the registered map or atlas; and

means for determining the position of the cursor with respect to the digitising surface in terms of the digitising surface's co-ordinate system;

wherein the relationship between the digitising surface's co-ordinate system and the co-ordinate system of the map, or the map of the atlas, registered with respect to the digitising surface can be determined from the data associated with the map.

18. A system as claimed in Claim 17, wherein the annunciating means is operable to indicate a required direction of movement of the cursor towards the current position on the map.

19. A system as claimed in any preceding claim, wherein:

the storing means is also operable to store a target position;

the processing means is also operable to calculate the distance between the stored position and the current position and/or the bearing of the stored and current positions relative to each other; and

the annunciating means is also operable to annunciate the calculated distance and/or bearing.

20. A map having:

its own co-ordinate system distinct from the wide-area co-ordinate system; and

data associated with the map from which the relationship between the map co-ordinate system and a wide-area co-ordinate system can be determined.

21. A series of maps having their own co-ordinate system(s) distinct from a wide-area co-ordinate system and data associated with the maps from which can be determined the relationship between the co-ordinate system(s) of the maps and the wide-area co-ordinate system.

22. A map as claimed in claim 20, or a series of maps as claimed in claim 21, and having the subsidiary features of any of claims 2 to 4, 7, 8 and 13 to 17.

23. A position locating apparatus, comprising:

means for receiving data associated with a traditional map having its own co-ordinate system

distinct from a wide-area co-ordinate system from which data the relationship between the map and wide-area co-ordinate systems can be determined;

means for storing the received data;

means for receiving data representing a position in terms of the wide-area co-ordinate system;

means for processing the received wide-area co-ordinate position and the stored data to determine the position in terms of the map co-ordinate system; and

means for annunciating to a user the determined map co-ordinate position.

24. An apparatus as claimed in Claim 23, further comprising means for receiving transmissions from a wide-area position transmitting system, for determining therefrom the position of the receiving means in terms of the wide-area co-ordinate system, and supplying the determined position to the position data receiving means.

25. A position locating apparatus as claimed in claim 23 or 24, and having the subsidiary features of any of claims 5, 6, 9 to 12 and 15 to 19.

26. A data carrier associated with at least one map and containing data from which the relationship between (a) co-ordinate system(s) of the map(s) and the wide-area co-ordinate system can be determined, the data being machine-readable or being encoded user-readable text.

27. A position locating system or apparatus, a map, series of maps or atlas, or a data carrier, substantially as described with reference to the drawings.

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| Patents Act 1977<br>Examiner's report to the Comptroller under Section 17<br>(The Search report) | Application number<br>GB 9523822.6 |
|---|---|
| **Relevant Technical Fields**<br>(i) UK Cl (Ed.O) G1F<br>(ii) Int Cl (Ed.6) G01C 21/00, 21/20 | Search Examiner<br>M D WALKER<br><br>Date of completion of Search<br>12 FEBRUARY 1996 |
| **Databases** (see below)<br>(i) UK Patent Office collections of GB, EP, WO and US patent specifications.<br><br>(ii) ONLINE: WPI | Documents considered relevant following a search in respect of Claims :-<br>ALL |

**Categories of documents**

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

| Category | Identity of document and relevant passages | | Relevant to claim(s) |
|---|---|---|---|
| X,Y | GB 2272519 A | (MASPRO..) page 8, line 9 to page 9, last line | X: 20, 21, 26<br>Y: 1-4, 22, 23, 24, 17, 18 |
| X,Y | GB 2191859 A | (QUBIT) see Abstract | X: 20-23, 26<br>Y: 1-4, 17, 18 |
| Y | GB 2043909 A | (FERRANTI) page 1, line 14 etc | 17, 18 |
| X,Y | EP 0559355 A1 | (PIONEER) see Abstract | X: 20, 21, 26<br>Y: 1-4, 17, 18, 23, 24 |
| X | EP 0382592 A1 | (THOMSON-CSF) | X: 20, 21, 26 |
| X | WO 95/22742 A1 | (PHILIPS) whole document | 1-5, 20-26 at least |

**Databases:** The UK Patent Office database comprises classified collections of GB, EP, WO and US patent specifications as outlined periodically in the Official Journal (Patents). The on-line databases considered for search are also listed periodically in the Official Journal (Patents).

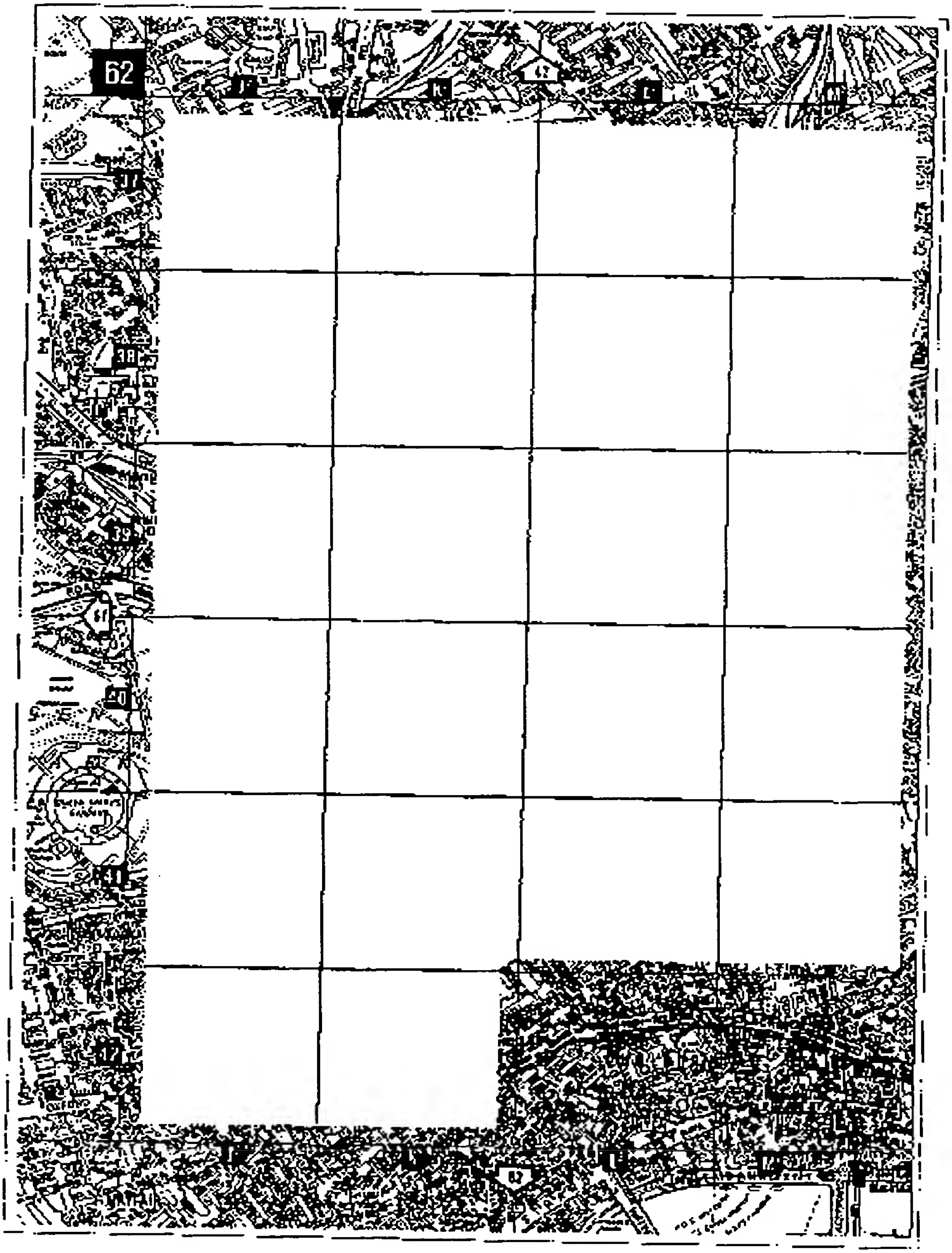

FIG. 1

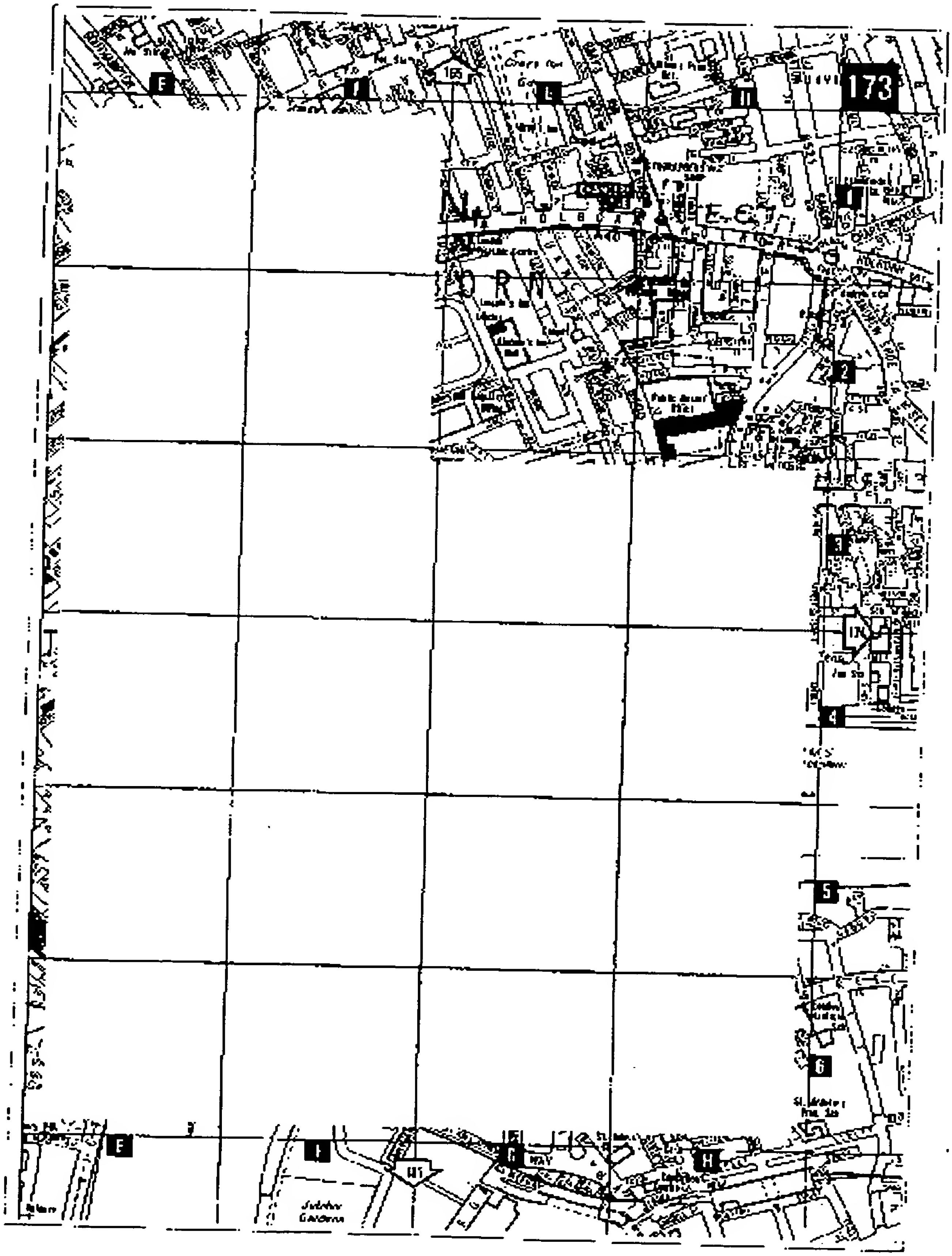

FIG. 2

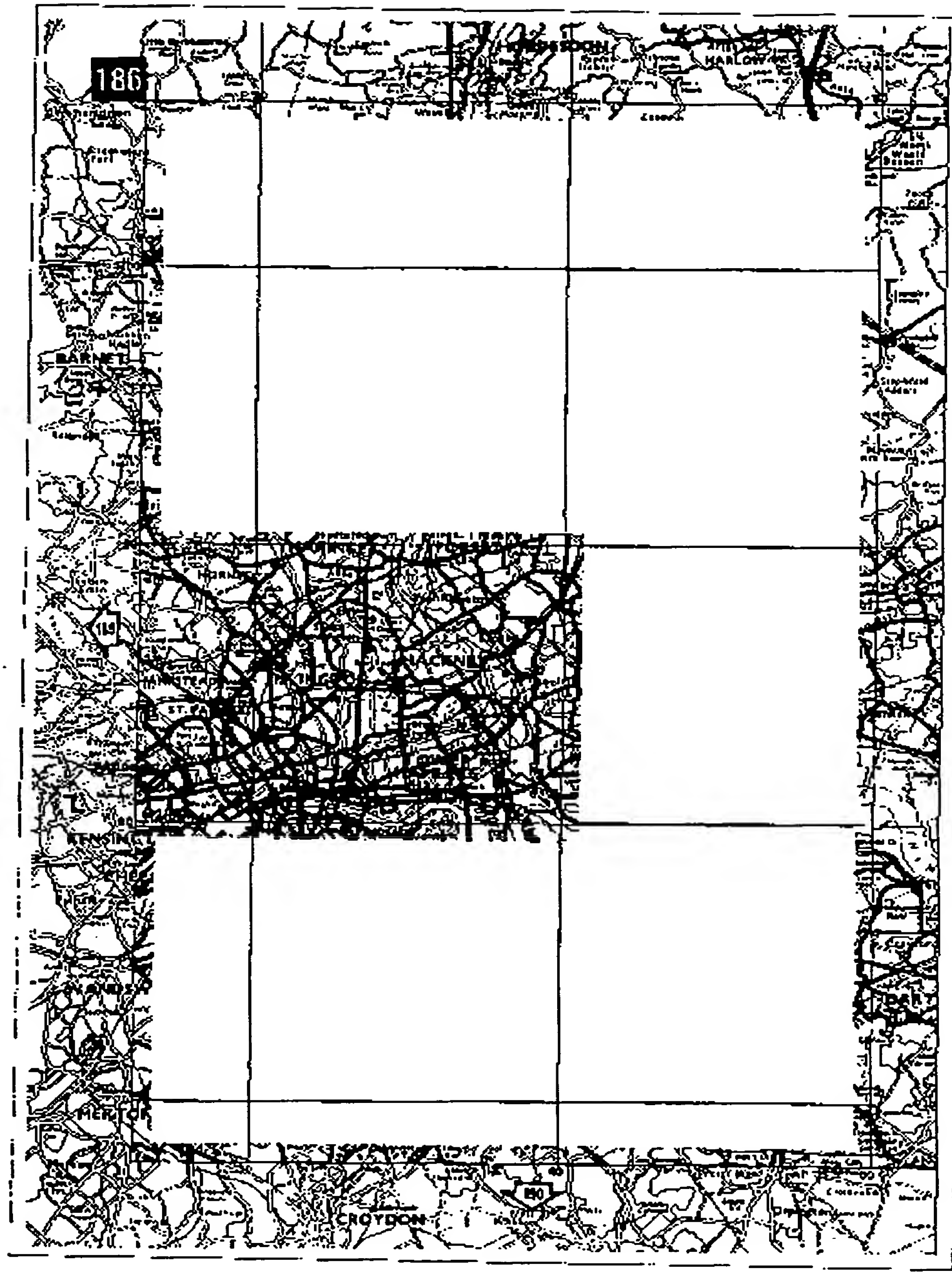


FIG. 3

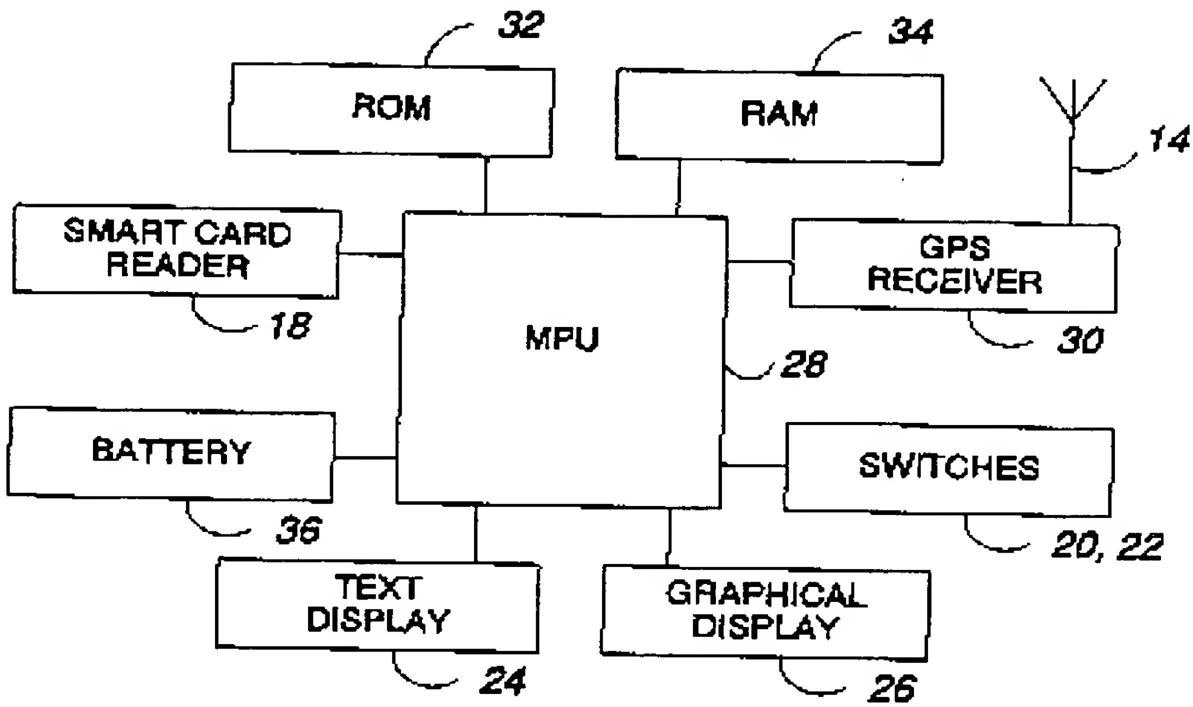
ROM
RAM
SMART CARD READER
MPU
GPS RECEIVER
BATTERY
SWITCHES
TEXT DISPLAY
GRAPHICAL DISPLAY
32
34
14
18
28
30
36
20, 22
24
26

FIG. 4

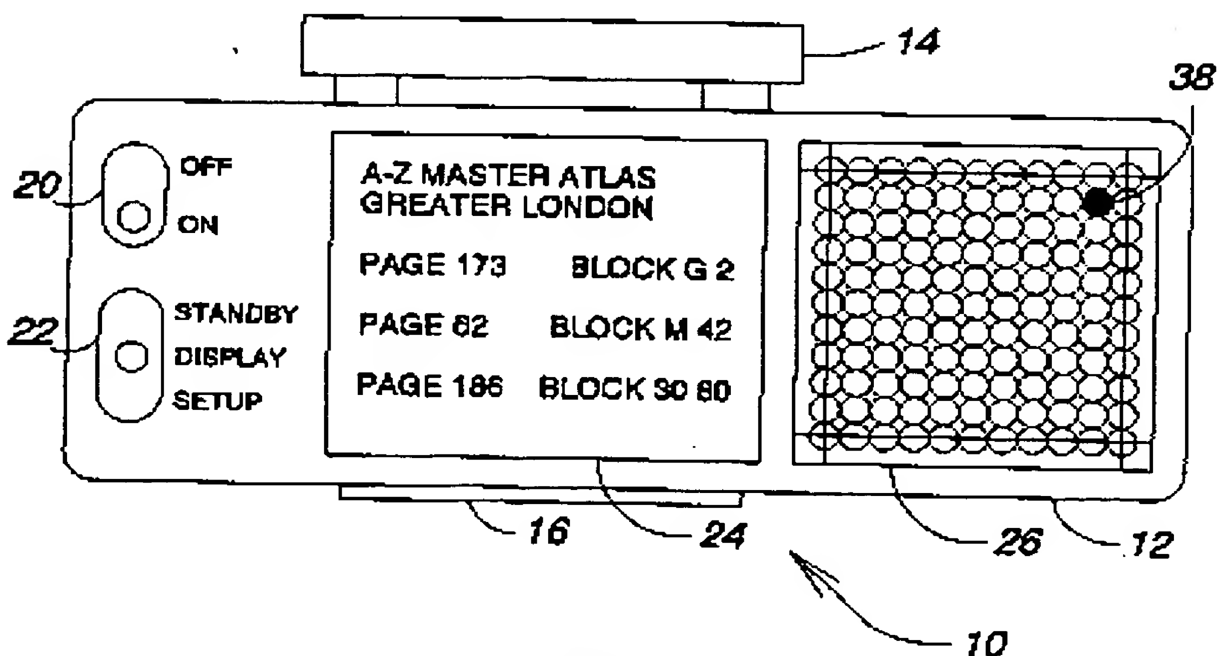
OFF
ON
STANDBY
DISPLAY
SETUP
A-Z MASTER ATLAS
GREATER LONDON
PAGE 173 BLOCK G 2
PAGE 62 BLOCK M 42
PAGE 186 BLOCK 30 80
14
38
20
22
16
24
26
12
10

FIG. 5

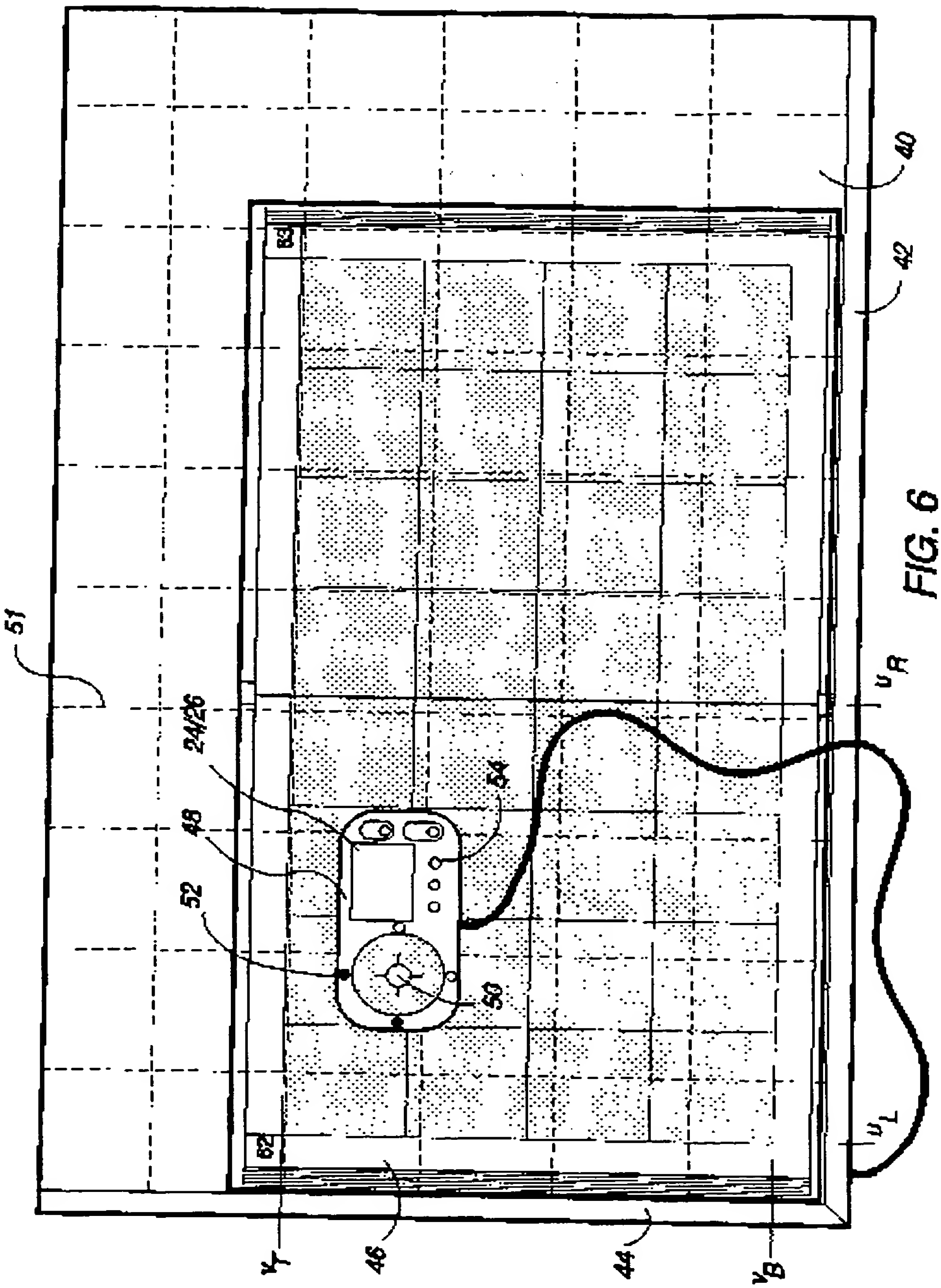


FIG. 6